

Cloud Radiative Forcing and Its Association with Atmospheric Circulation over East Asia

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The cloud radiative forcing (CRF**) at the top of the atmosphere (**TOA**) , the surface and in the atmosphere is essential to improve our understanding of earth's climate.**

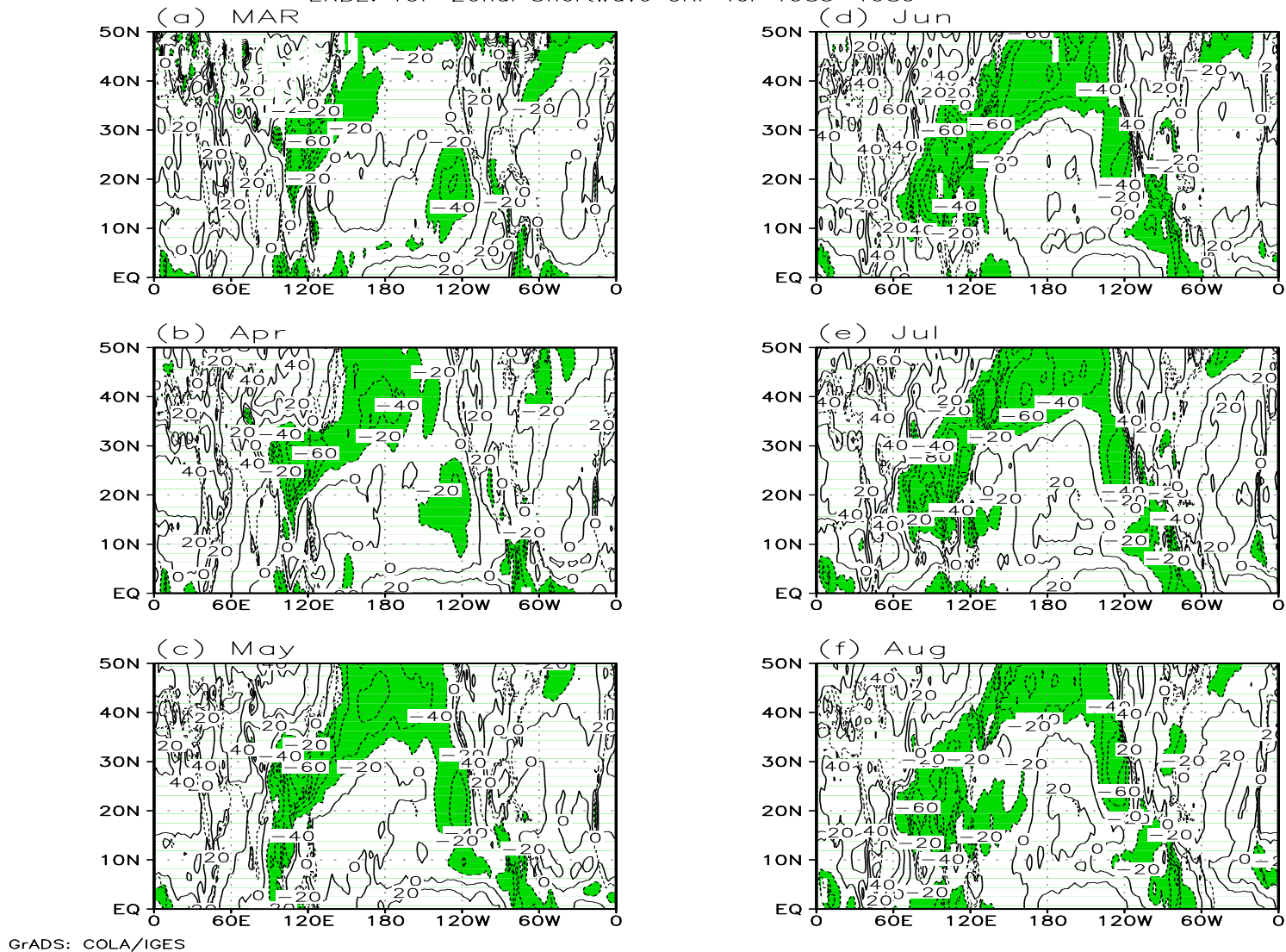
Two questions will be discussed:

- 1. The seasonal variations of the CRF at the TOA**
- 2. The inter-annual variations of the CRF at the TOA over East Asian monsoon region (105-122° E; 23-34° N) and its association with circulation patterns**

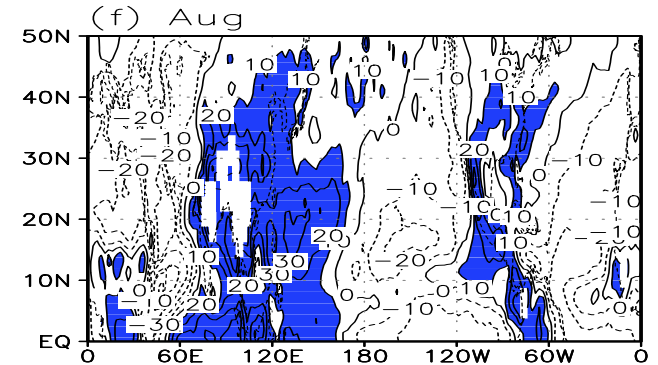
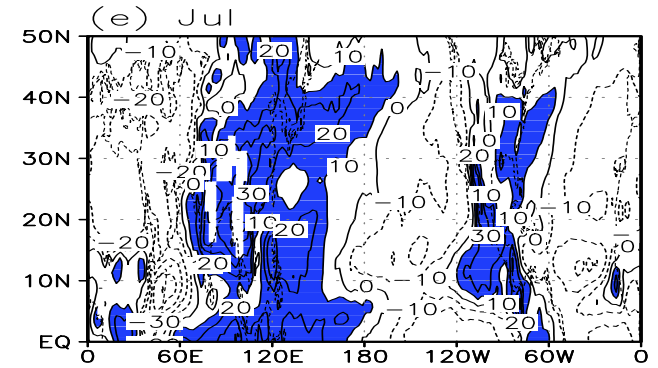
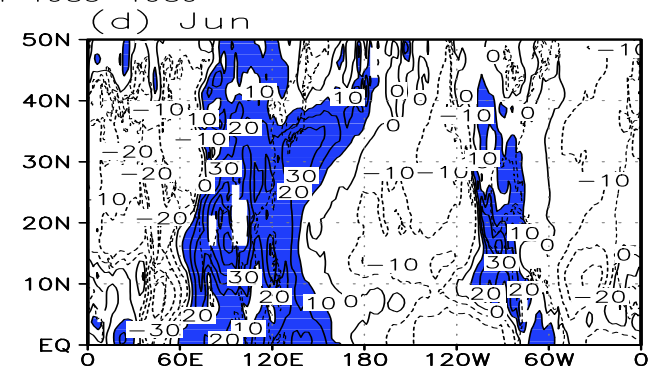
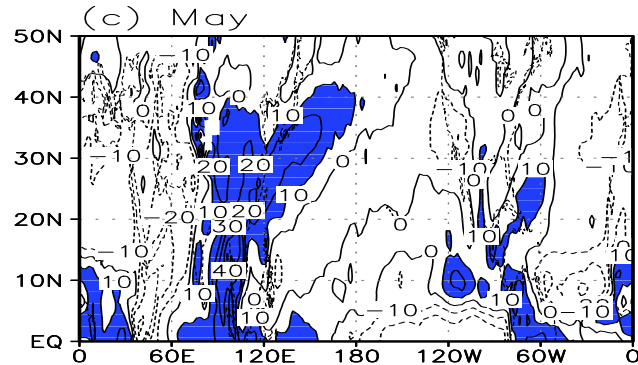
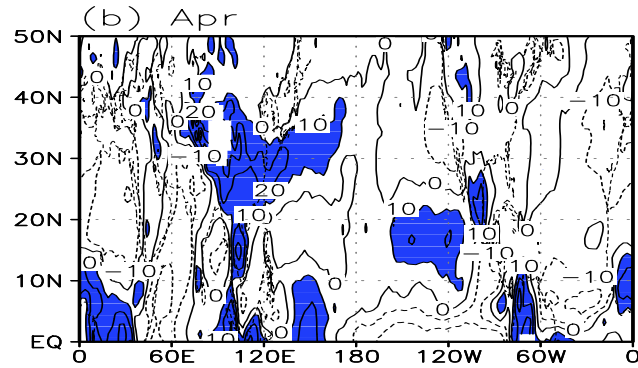
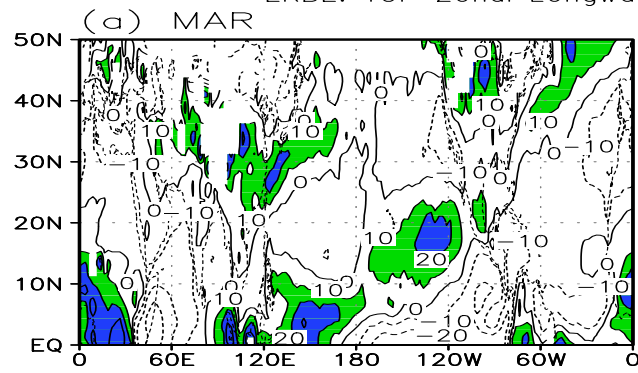
Data:

- The CRF data is from Earth Radiation Budget Experiment (**ERBE**) satellite observations during 1985~1989.
Climatologic mean of the CRF averaged by 1985-1989.
- The reanalysis product has 12 levels on 2.5° latitude by 2.5° longitude grid dataset are from **NCAR/NCEP** reanalysis data (Kalnay et al 1996).

The seasonal variations of CRF at TOA in northern hemisphere



The fig shows the zonal anomaly of SW-CRF at TOA. The maximum anomalous values appeared over East Asian monsoon region that means the cooling in East Asian monsoon region is larger than the other areas.



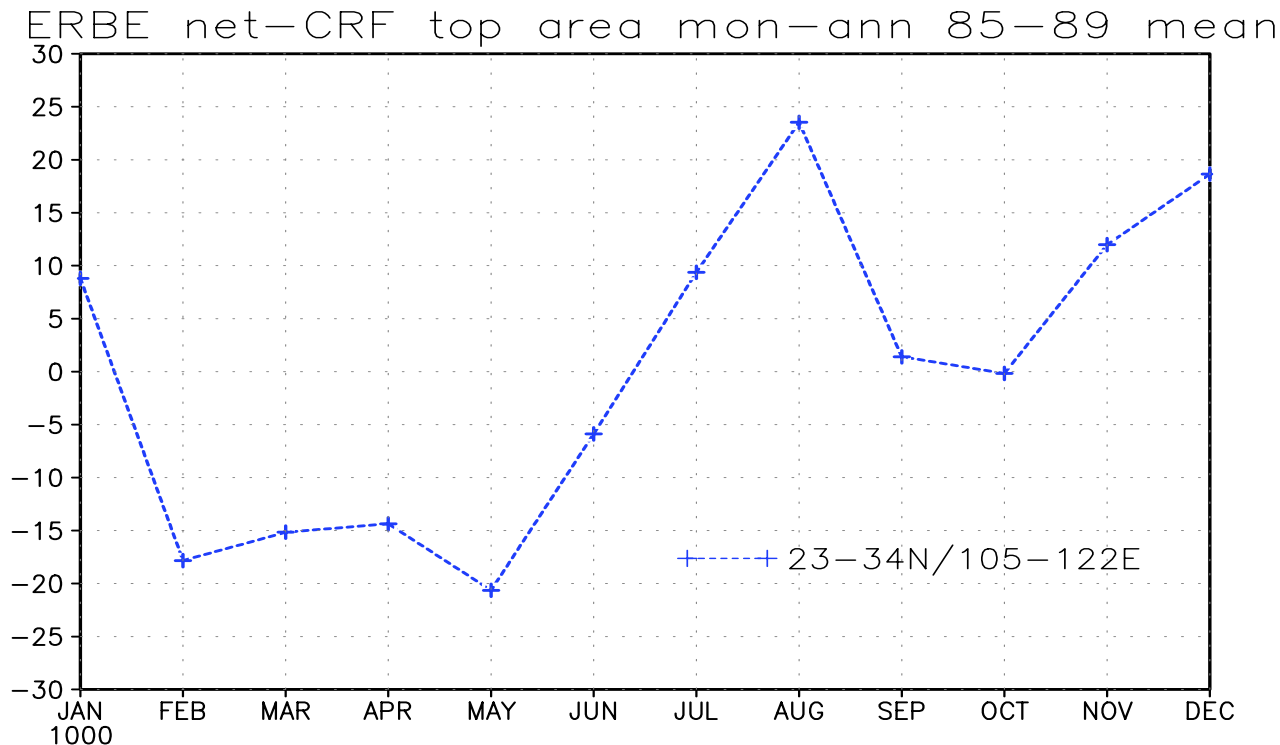
GrADS: COLA/IGES

The fig shows the zonal anomaly of LW-CRF at TOA. The maximum anomalous values appeared over East Asian monsoon region that means the heating in East Asian monsoon region is larger than the other areas.

The strongest cooling and heating appeared over East Asia monsoon region during March-August respectively.

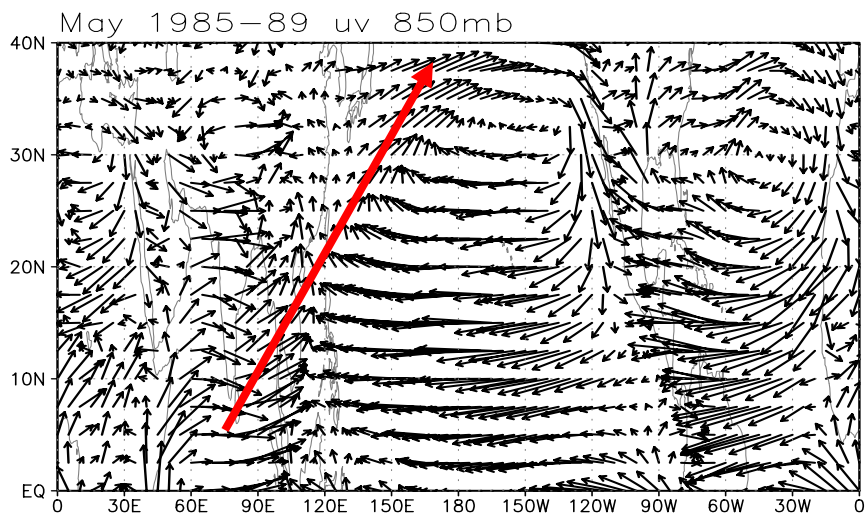
So, the study focus on the Net CRF which presents by the summation of the SW and LW CRF over East Asian monsoon region (23-34N/105-122E).

Fig.3 shows the monthly anomalous **net CRF** which is the monthly value minus annual mean, and the monthly **net CRF** averaged by 23-34N/ 105-122E (East Asian monsoon area).

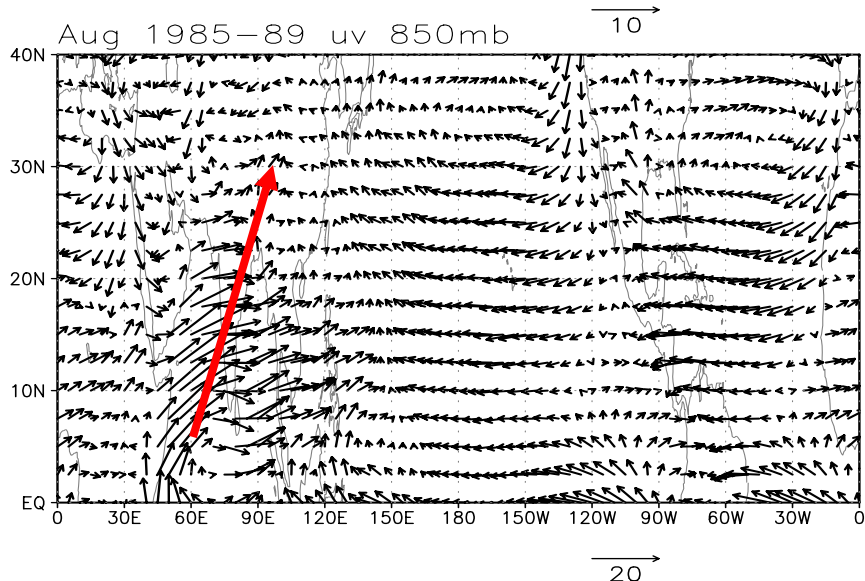


It showed that the relative lowest value occurred in May and highest value in August. It means that the strongest cooling is in May and the weakest cooling is in August, and there is linear varying during May to August.

The fig shows wind at 850hPa averaged by 1985-1989

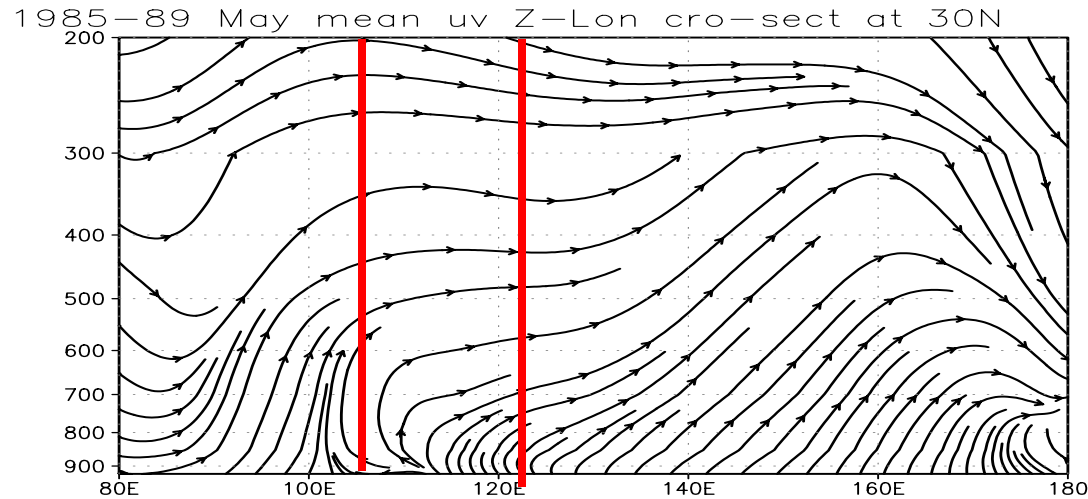


In May or August the stronger southwesterly wind occurred over East Asia monsoon region.

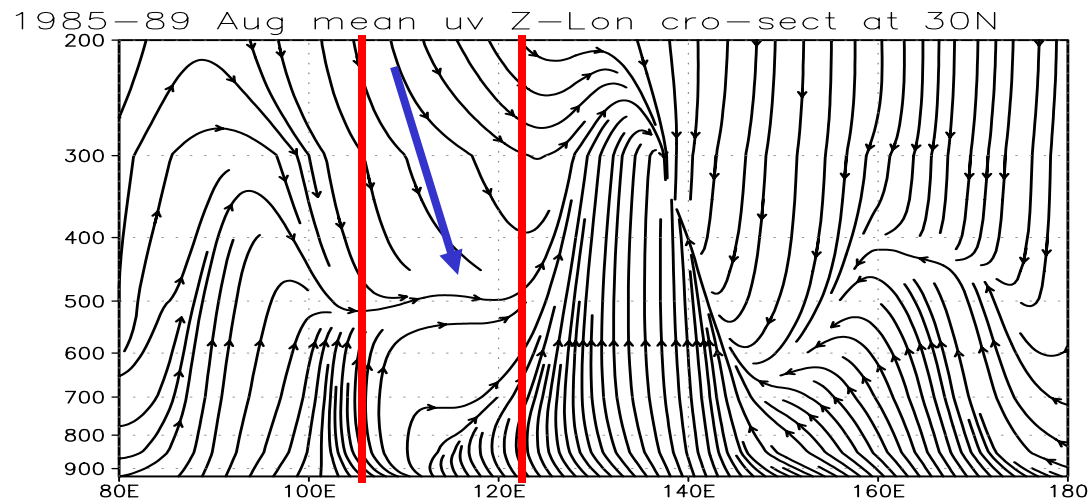


However the southwesterly wind reached latitude was 40N in May, and 30N in August.

May and Aug vector wind, it is altitude & longitude cross section along 30N averaged by 1985-1989. It showed the upward airflows over East Asia monsoon region weakened in August.



In May, there is the upward airflows from surface to 200mb.



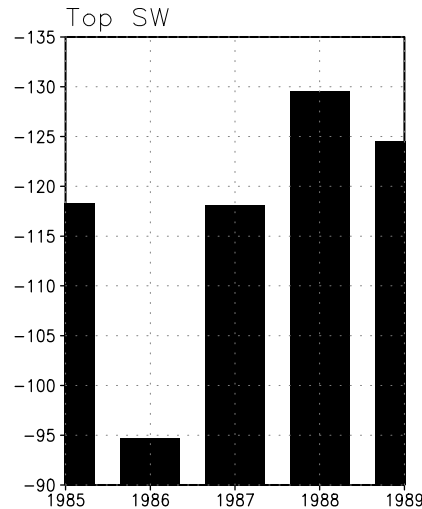
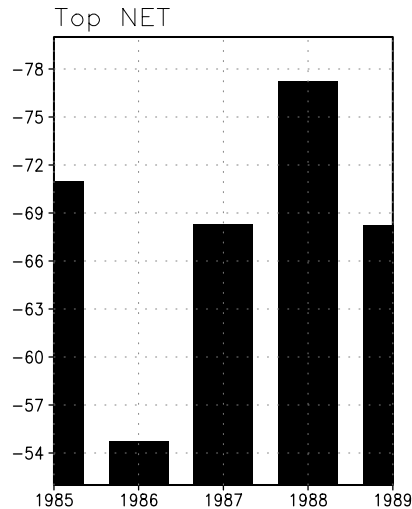
In August, under 500hPa there is upward airflows and above 500hPa there is downward airflows over East Asia monsoon region .

The southwesterly airflows over East Asia monsoon region is substantial for seasonal variations of CRF over East Asia monsoon region.

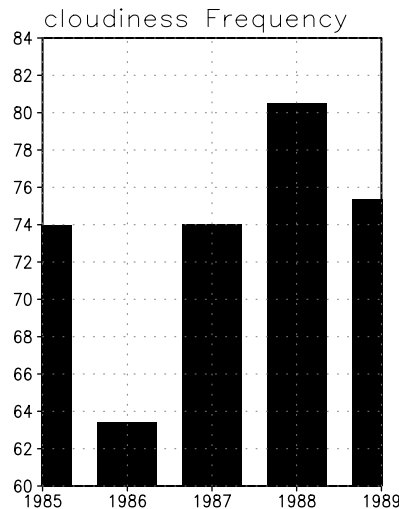
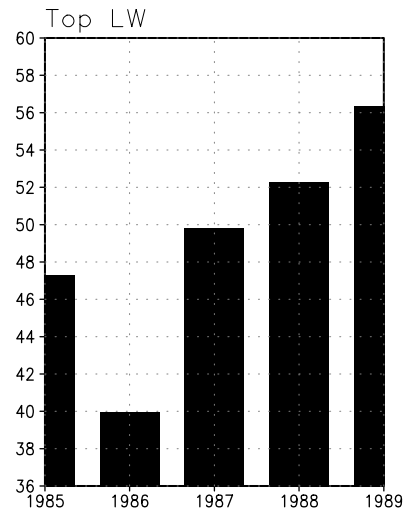
Because the wind field in atmospheric circulation is different year after year, the relationships between wind field and CRF at TOA over East Asia monsoon region will be discussed.

**The annual variations of the
CRF at TOA and its associated
with circulation patterns**

May CRF & Cloudiness Frequency that Averaged by 105-122E/23-34N

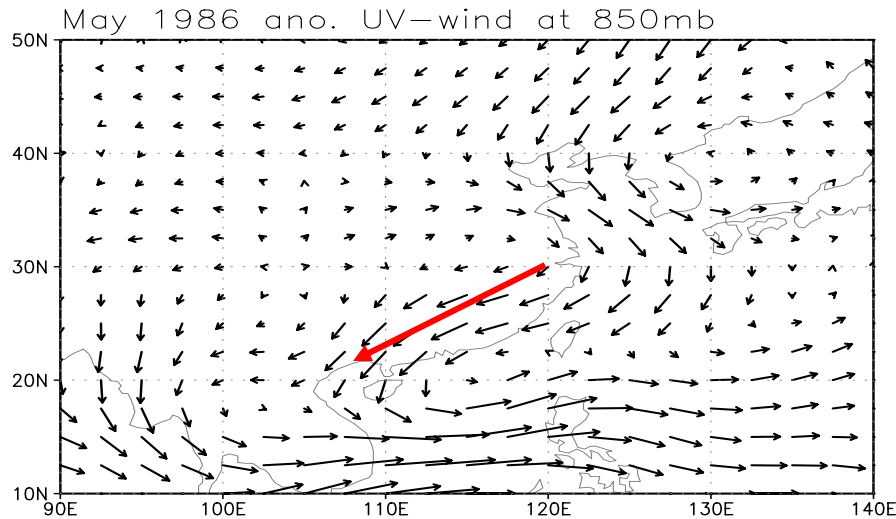


There is the inter-annual variation for CRF at TOA over East Asian monsoon region in May.

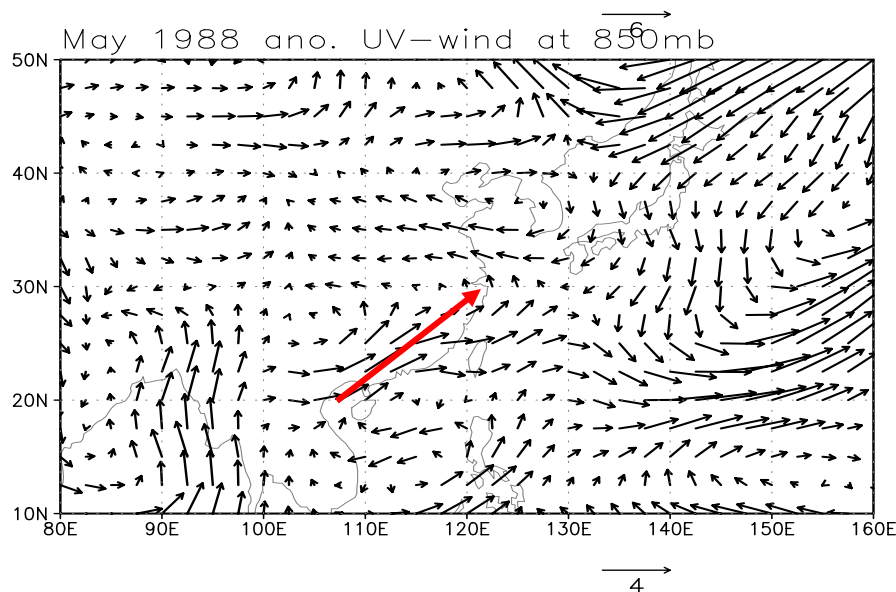


The weaker case looked in 1986 and stronger case in 1988 for CRF over East Asian monsoon region .

May: anomalous wind at 850hPa (a) 1986 (b) 1988



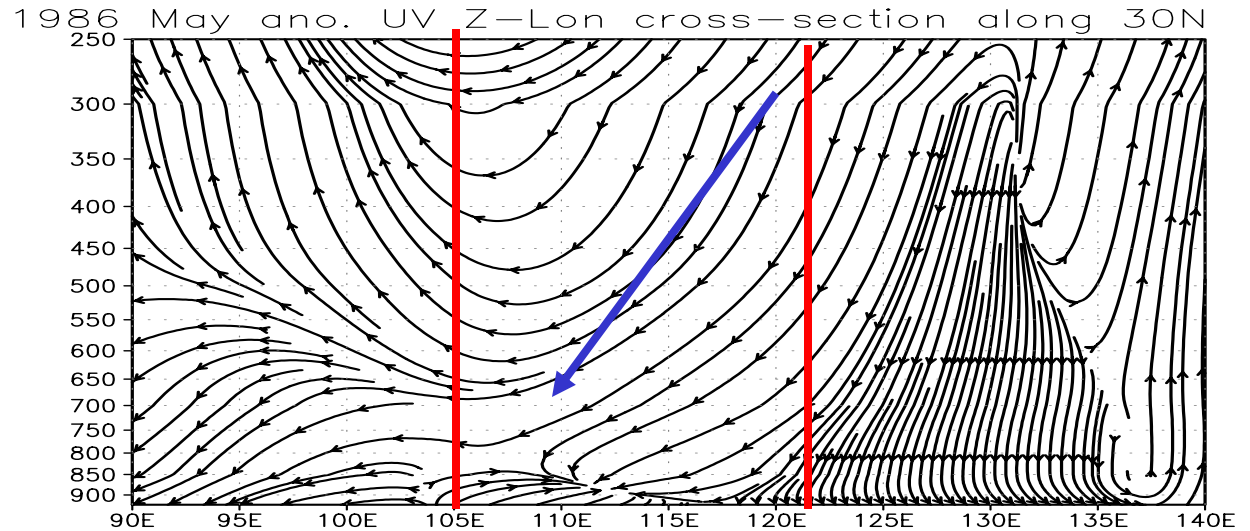
The anomalous northeasterly airflows was over East Asia monsoon region which means the southwesterly wind looked weaker in 1986 than normal.



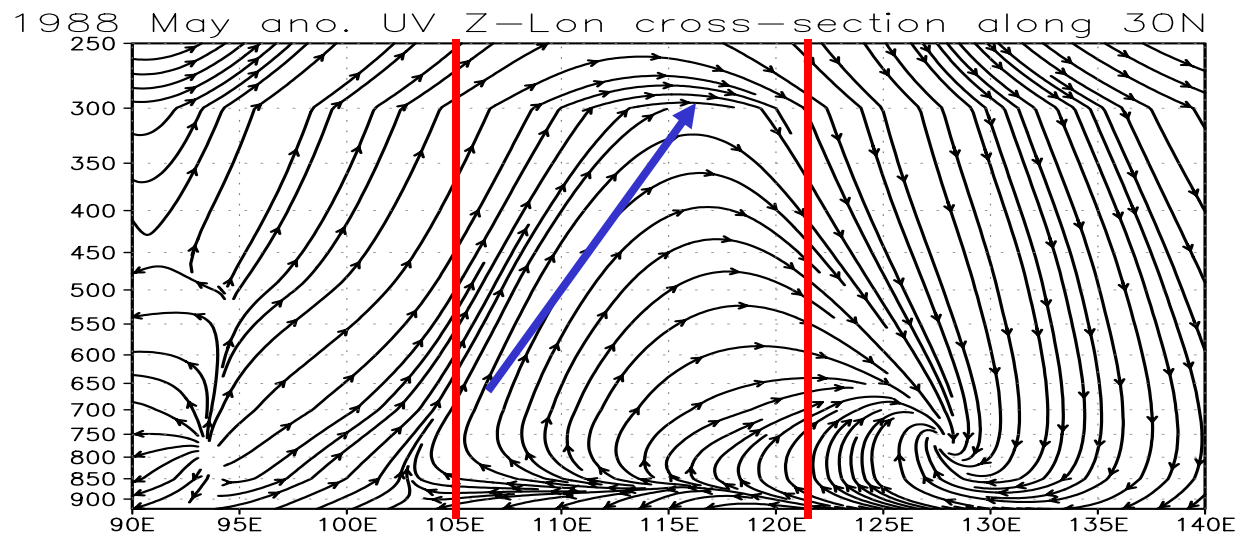
The anomalous southwesterly wind was over East Asia monsoon region which means southwesterly wind looked stronger in 1988 than normal.

May: the anomalous vector wind along 30N, it is altitude & longitude cross section 1986(a) and 1988 (b)

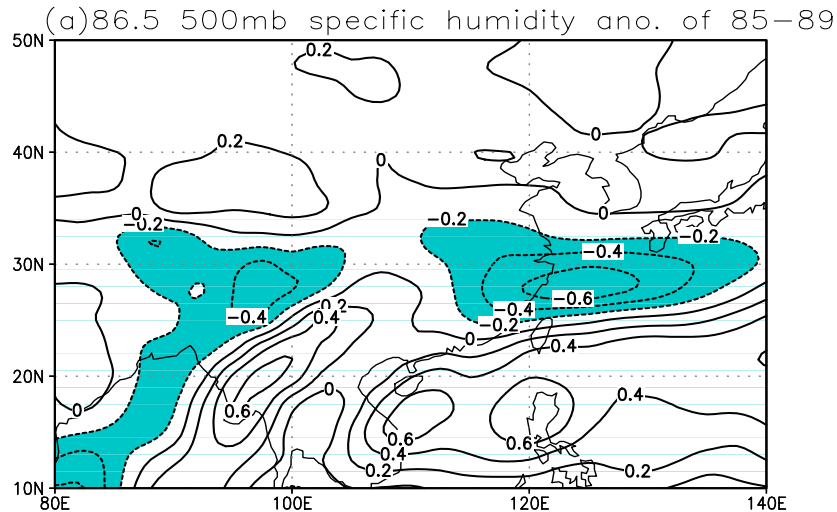
There was anomalous downward airflows, the upward motion became weaker in 1986 than normal.



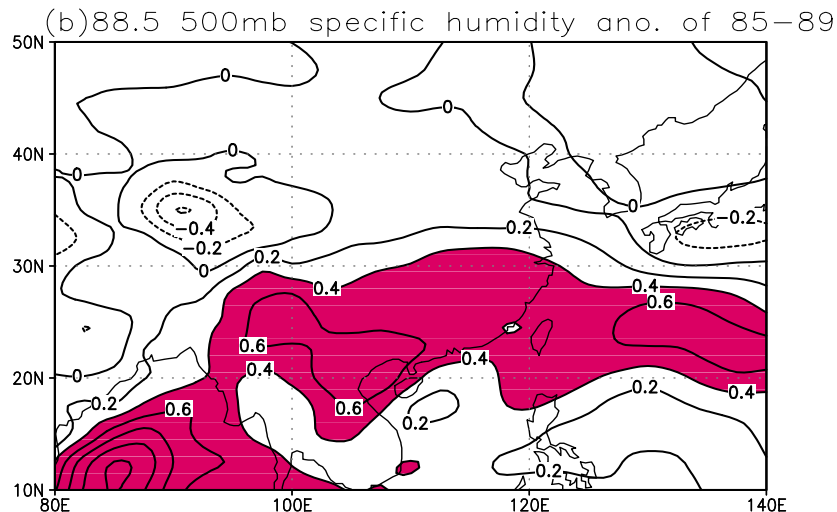
There was anomalous upward motion, the upward motion became stronger in 1988 than normal.



May: the anomalous humidity (unit: g/kg) at 500hPa (a) 1986; (b) 1988

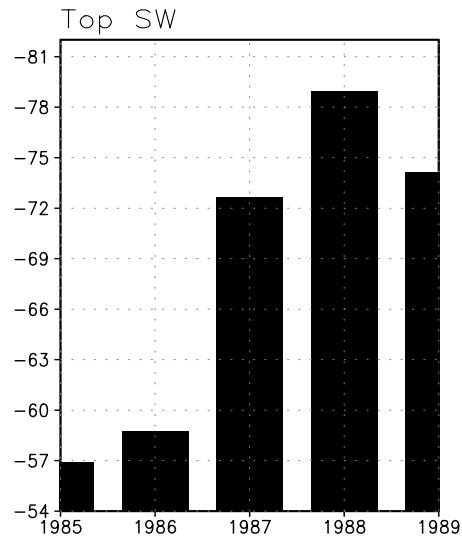
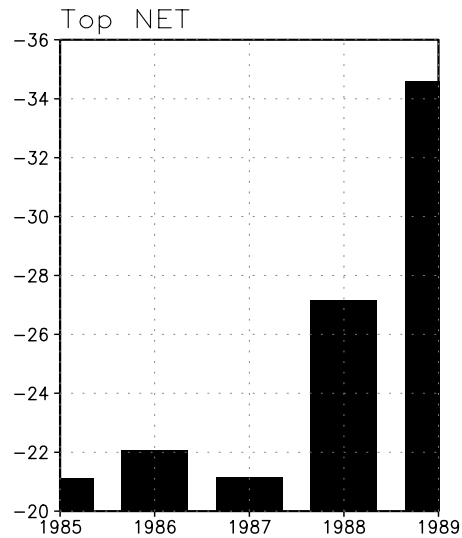


Due to the upward airflows became weaker in May 1986 than normal, resulting the anomalous negative center of the humidity over east Asian region.

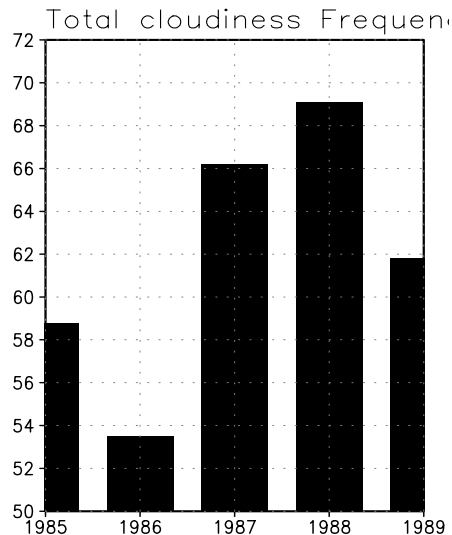
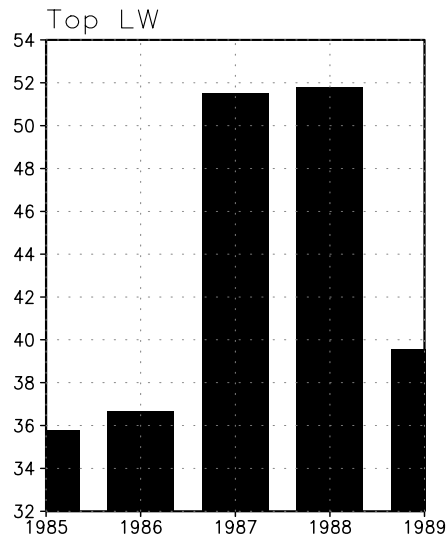


Because the upward airflows became stronger in May 1988 than normal, resulting the anomalous positive center of the humidity over east Asian monsoon region.

August: CRF & Cloudiness Frequency Averaged by 105-122E/23-34N

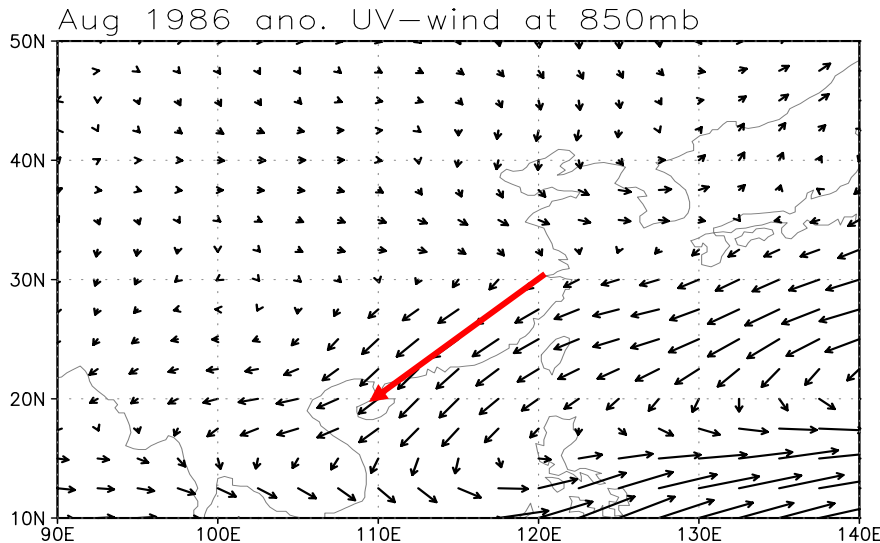


There is the inter-annual variation for CRF at TOA over East Asian monsoon region in Aug.

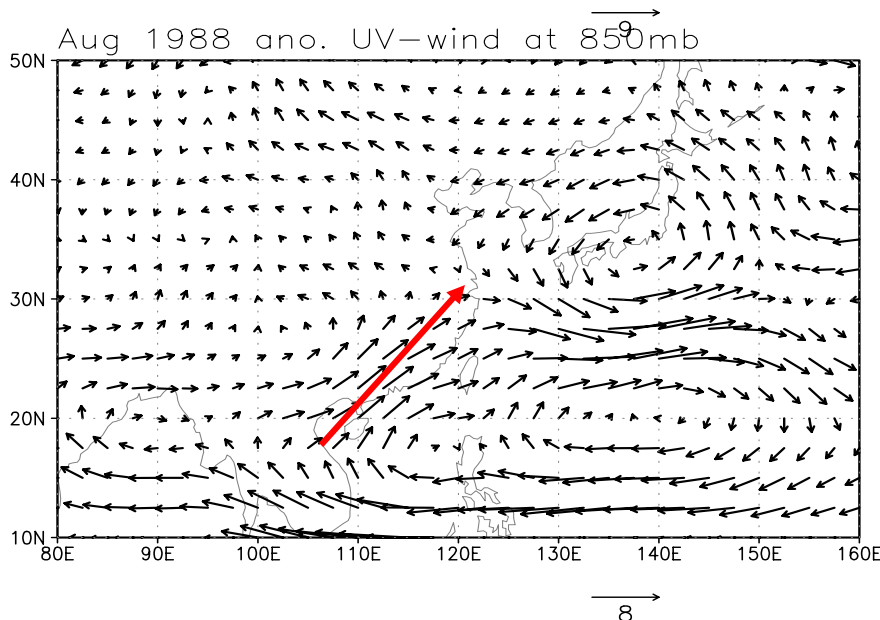


The weaker case looked in 1986 and stronger case in 1988 for CRF over East Asian monsoon region .

August: anomalous wind at 850hPa (a) 1986 (b) 1988



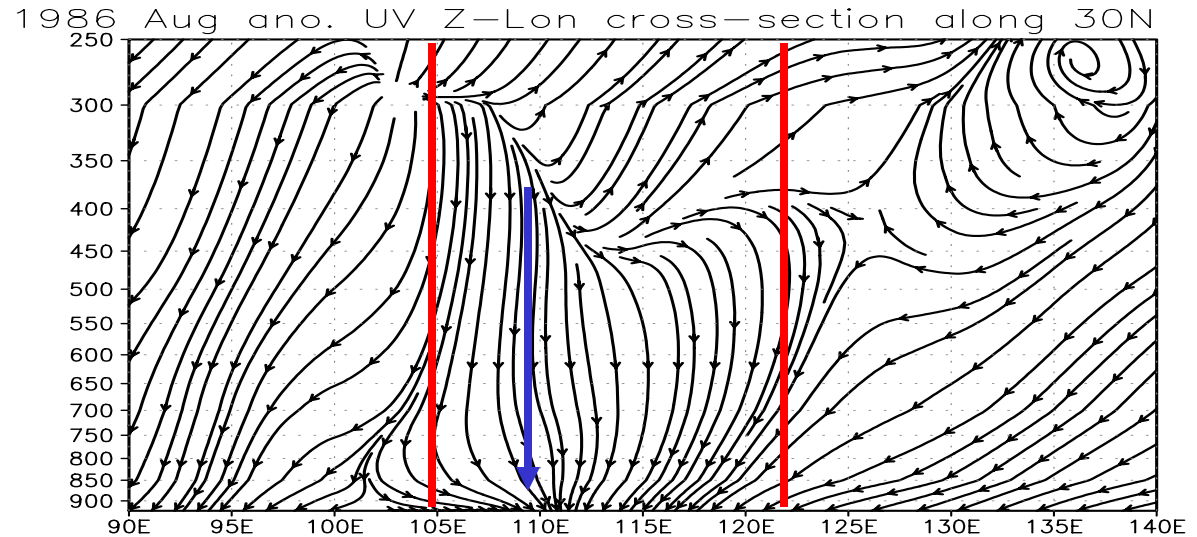
The anomalous northeasterly airflows was over East Asia monsoon region which means the southwesterly wind looked weaker in 1986 than normal.



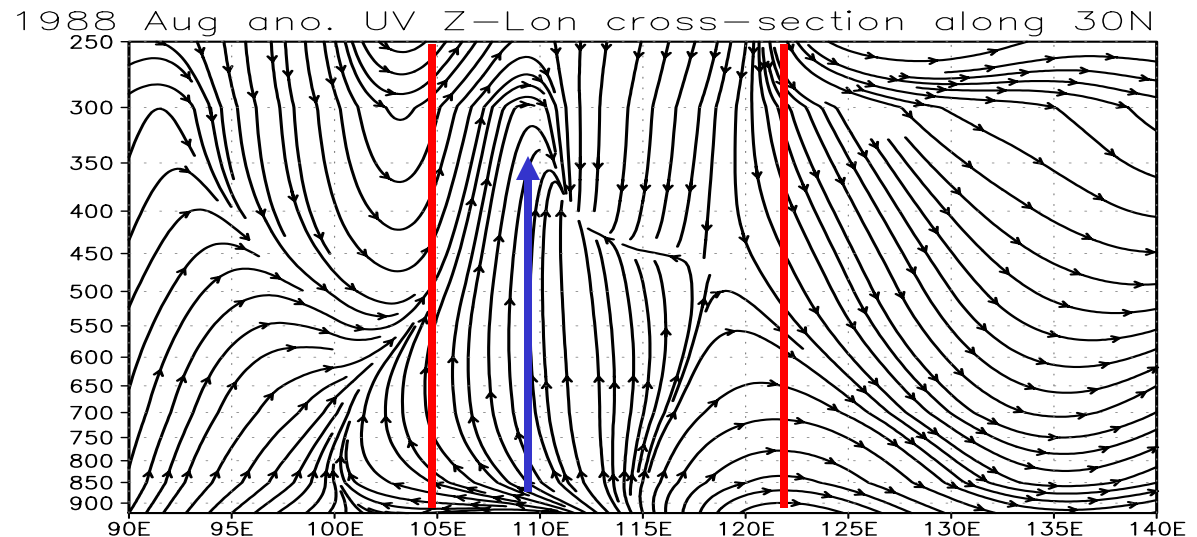
The anomalous southwesterly wind was over East Asia monsoon region which means southwesterly wind looked stronger in 1988 than normal.

August: the anomalous vector wind along 30N, it is altitude & longitude cross section 1986(a) and 1988 (b)

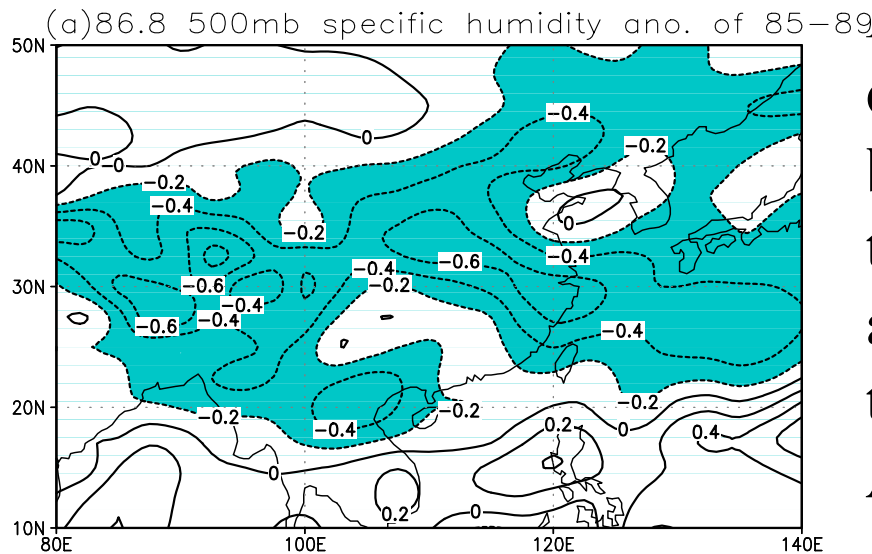
There was anomalous downward airflows, the upward motion became weaker in 1986 than normal.



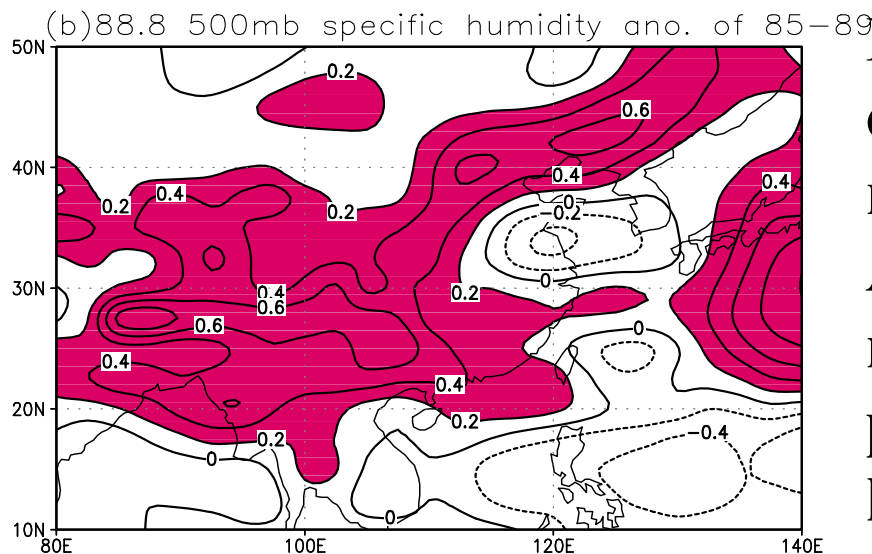
There was anomalous upward motion, the upward motion became stronger in 1988 than normal.



August: the anomalous humidity (unit: g/kg) at 500hPa (a) 1986; (b) 1988



Due to the upward motion over east Asian region became weaker in Aug 1986 than normal, resulting the anomalous negative center of the humidity was over east Asian region.



Because the upward motion over east Asian monsoon region became stronger in Aug 1988 than normal, resulting the anomalous positive center of the humidity was over east Asian region.

When the upward motion over east Asian monsoon region became stronger (weaker), the humidity and cloudiness increased (decreased), resulting intensity of CRF changed.

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Summary

1. The largest anomaly for **CRF** at TOA was over East Asia monsoon region;
2. The CRF over East Asia monsoon region is sensitive to the large-scale circulation, especially southwest wind over East Asia monsoon region.
3. The southwesterly wind over East Asia monsoon region at 850hPa strengthened in 1988, resulting the upward motion over East Asia monsoon region intensified, and the atmospheric mass became moister, and causing the CRF at TOA over East Asia monsoon region became stronger in 1988 than 1986.

Thank you !

ERBE /ISCCP_c2: Monthly High-Cloud Frequency Anomalous percentage for averaged by 1985-1989

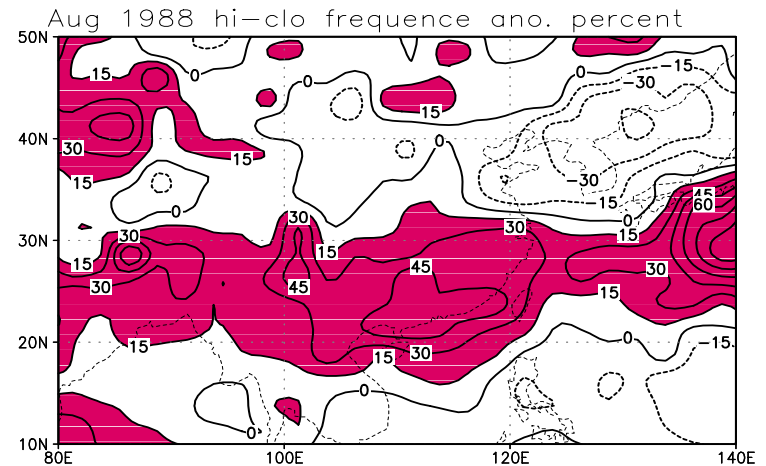
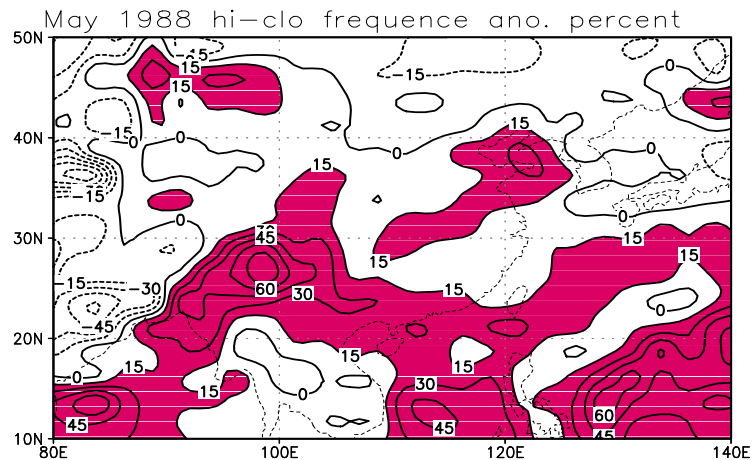
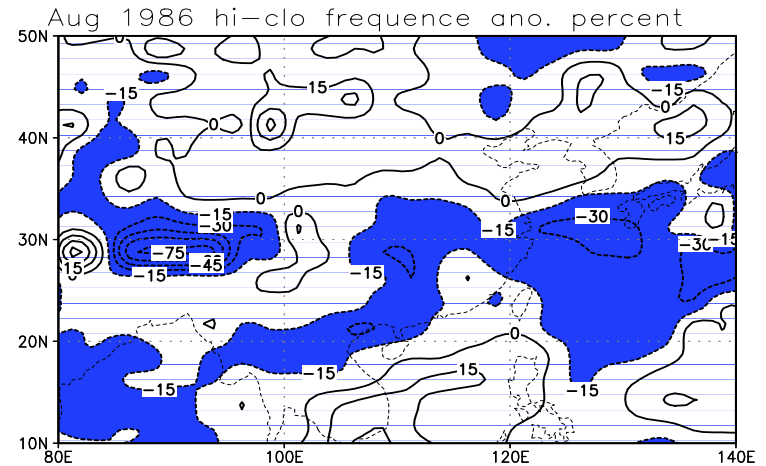
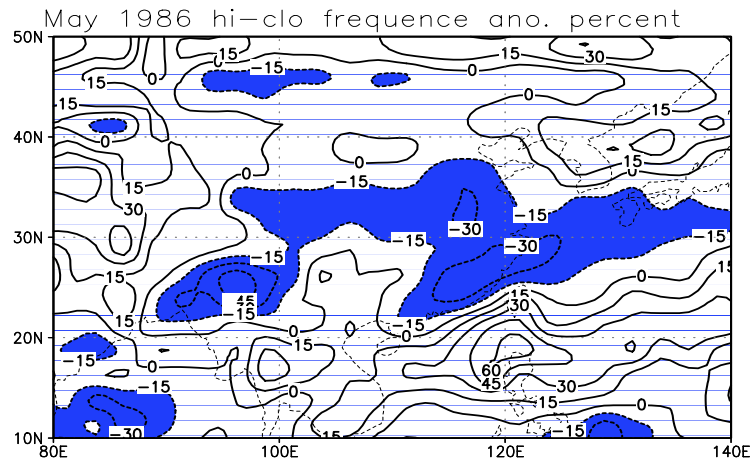


Fig.11: August anomaly in 1986 and 1988 (August mean 1985-1989)

Left: 500hPa Specific humidity anomaly Right: 700hPa vertical velocity anomaly

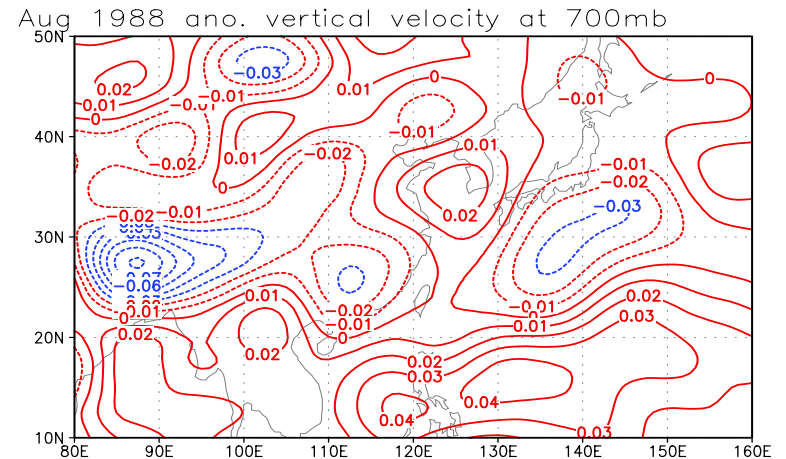
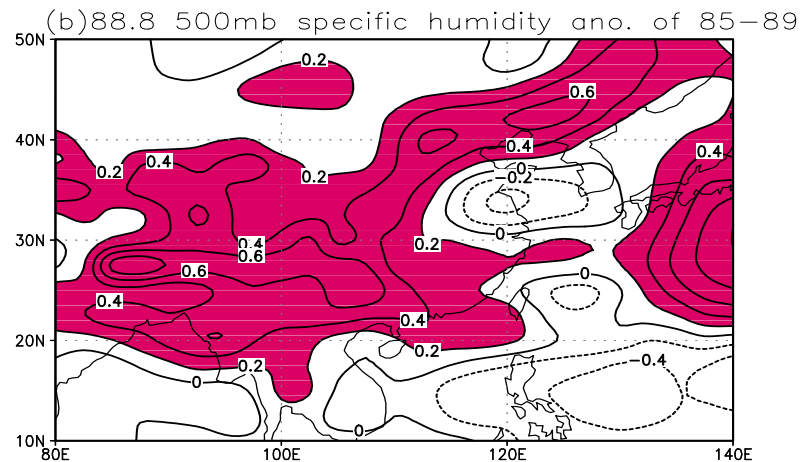
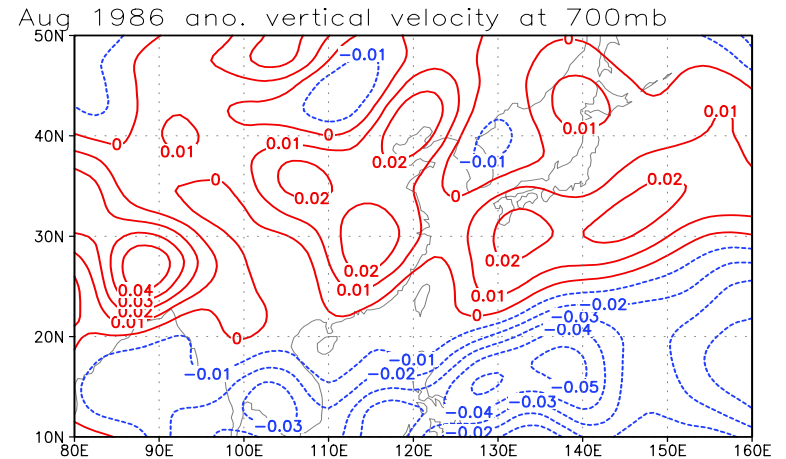
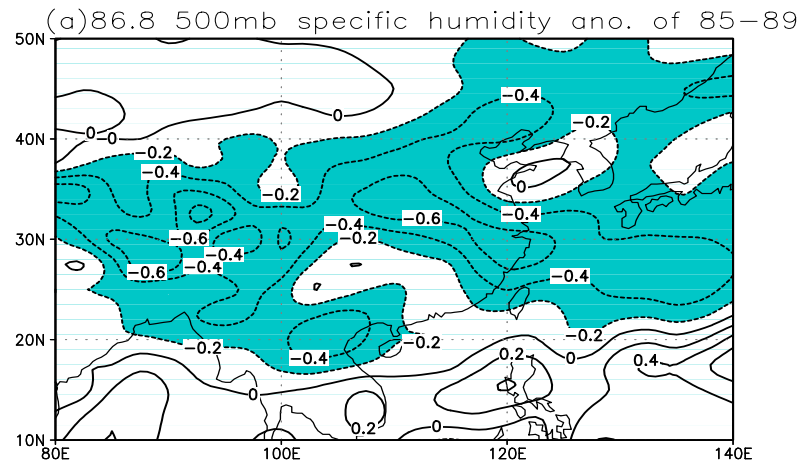
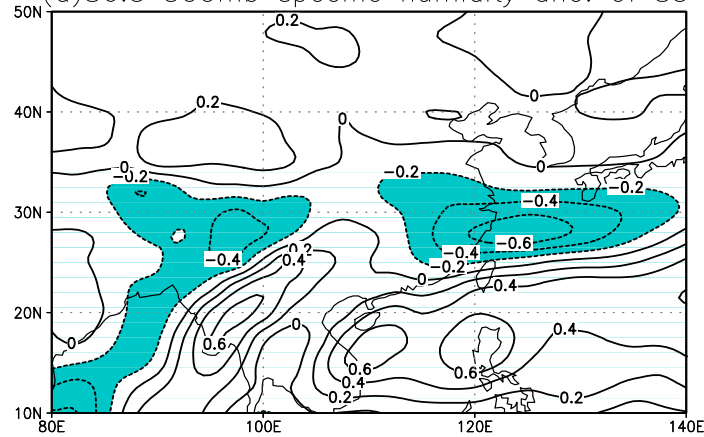


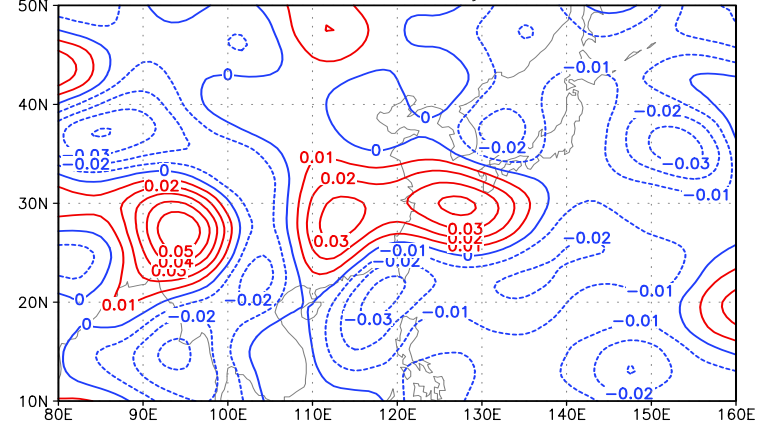
Fig. 8: May anomaly in 1986 and 1988 (May mean 1985-1989)

Left: 500hPa Specific humidity anomaly Right: 700hPa vertical velocity anomaly

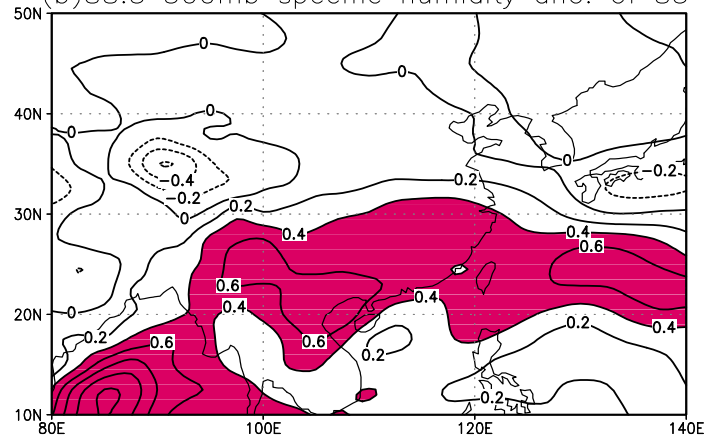
(a) 86.5 500mb specific humidity ano. of 85-89



May 1986 ano. vertical velocity at 700mb



(b) 88.5 500mb specific humidity ano. of 85-89



May 1988 ano. vertical velocity at 700mb

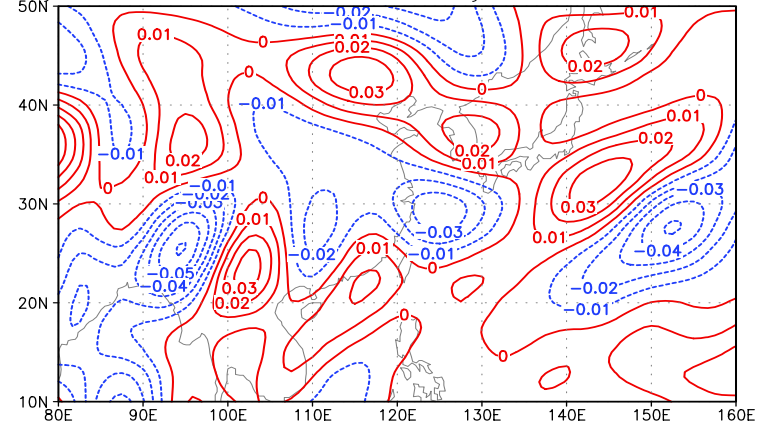


Fig.4: May & August averaged by 1985-1989 respectively

Left: 700-300hPa Specific humidity mean Right: 700-200hPa vertical velocity mean

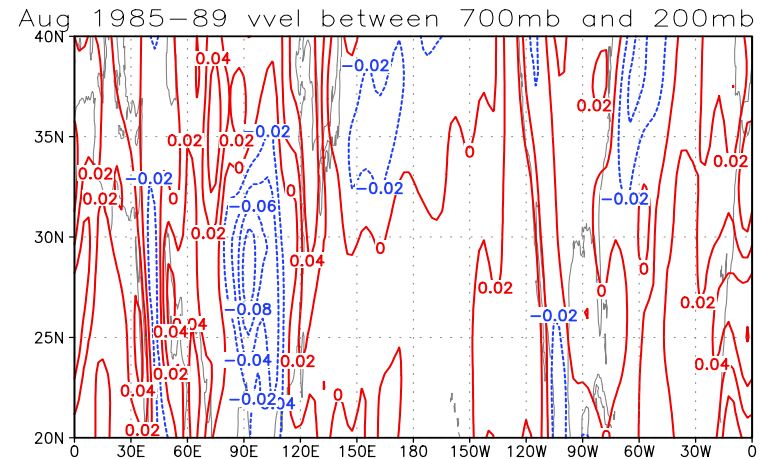
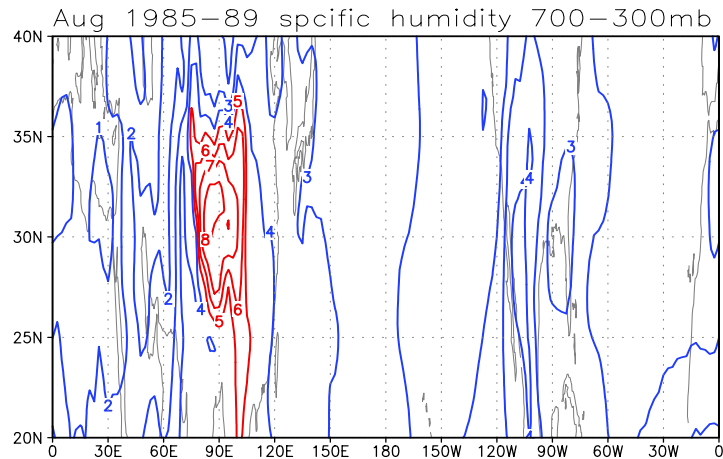
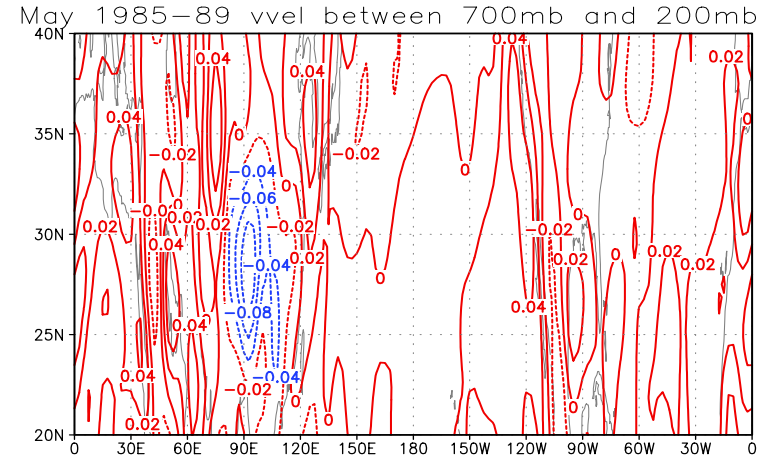
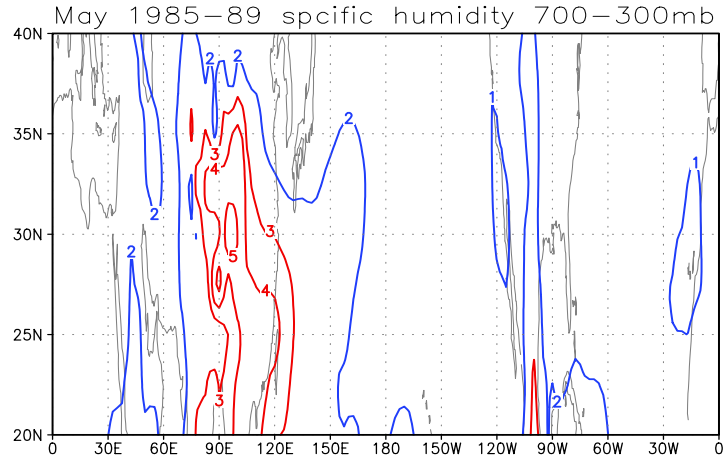


Fig.13: Total cloudiness anomaly in May and August (mean 1985-1989)
Left :May 1986 & 1988 ; Right:Aug 1986 &1988

